THE EFFECTS OF THE TRANSCENDENTAL MEDITATION PROGRAM ON THE EXERCISE PERFORMANCE OF PATIENTS WITH ANGINA PECTORIS

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Patients with angina pectoris were found to have an improved tolerance to exercise after participating in the Transcendental Meditation program for eight months. Improvements included an ability to exercise for longer periods and to endure a higher work load. — EDITORS

Sixteen patients with documented angina pectoris were exercised on a bicycle ergometer to an end point of moderately severe angina pectoris. Electrocardiograms and blood pressure were taken at one-minute intervals. The reliability of the testing procedure was gauged from the reproducibility of the values of both maximum ST segment depression and maximum double product at the end point of the tests. Patients were tested, and then ten began the Transcendental Meditation program. All patients were retested after eight months, and the ten patients who participated in the Transcendental Meditation program showed a 14.5% increase in exercise tolerance, an 11% increase in maximum work load, a 16% increase in delay of onset of ST segment depression, and a 7.25% decrease in double product after three minutes of exercise. There was no significant change in the control patients.

INTRODUCTION

The Transcendental Meditation (TM) technique is currently available as a systematic, easily learned technique. Marked generalized lowering of metabolic function and a deep state of rest resulting from this mental technique have been documented by previous work (30). Physiological correlates of the mental state produced by the TM technique (described as restful alertness) seem to indicate a quiescence of sympathetic activity or a "wakeful hypometabolic physiologic state" (32). The regular practice of this technique has a demonstratable, persisting, and beneficial effect on hypertension (2, 4, 5), asthma (35), anxiety (13), and the autonomic response to stress (22).

Reduction in sympathetic activity would benefit the patient with angina pectoris by modifying determinants of myocardial oxygen consumption (MVO2) (10, 28). Assessment of the effect of any therapeutic intervention on angina pectoris is best demonstrated through exercise performance utilizing a carefully designed exercise stress test protocol (24), and reproducibility of testing results requires a specifically defined symptomatic end point (27).

The present study was designed to evaluate the effect over an eight-month period of the TM program on the exercise performance of patients with documented, stable angina pectoris.

METHODS

SUBJECTS—All patients investigated had had classic, stable angina pectoris for six months or more (see table 1). None had had bypass surgery. Presence of coronary artery disease was demonstrated by selective coronary arteriography in all patients except two, who had documented myocardial infarctions.

Patients were selected sequentially from the cardiac catheterization records of the Cardiopulmonary Laboratory and from the cardiology clinic. Patients were screened by a bicycle ergometry test for the presence of typical angina pectoris and by positive stress testing for eligibility to enter the study. Informed consent was obtained from all patients. The first 12 eligible patients were placed in the TM program group to receive instruction in the Transcendental Meditation technique. Nine other patients were similarly selected to serve as a control group and were told they would receive instruction in the TM technique after an eight-month delay.

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Two patients in the TM program group and three patients in the control group did not complete the study because of intercurrent conditions; one dropped out of the study and sought bypass surgery at another hospital; two developed intercurrent illness; and two could not be withdrawn from propranolol at the time of retesting. Sixteen patients successfully completed the study—ten in the Transcendental Meditation program group and six in the control group.

On all of the patients who completed the study, except two in the TM program group and one in the control group, hemodynamic data revealed normal ventricular function as characterized by ejection fraction and left ventricular contractility (see table 2). Four of the TM program group and one of the control group, however, had elevated left ventricular end diastolic pressure at rest.

EXERCISE TESTING—Patients were exercised, in a fasting state, on an upright bicycle ergometer (Godart, DeBilt, Holland) calibrated in watts and pedaled steadily at about 55 rpm, under constant environmental temperature. Propranolol was tapered and withdrawn at least one week prior to testing. Nitrates were omitted for at least 12 hours.

All patients underwent at least one preliminary exercise test to familiarize themselves with the bicycle and to assess an appropriate work load schedule before definitive testing. Individual work load schedules of three-minute increments were chosen so that angina was elicited in the second or third work load, and so that supramaximal exertion was avoided. The two most used work load schedules were 25 - 50 - 75 watts and 25 - 75 - 125 watts. The individual work load schedules initially determined were then maintained throughout the entire study.

All exercise testing was performed by the same investigator. Blood pressures were recorded by a mercury sphygmomanometer while subjects were at rest on the bicycle ergometer (resting measurement), at the end of every one-minute period during the test, and at the exact end point of the test. The electrocardiogram (EKG) was monitored continuously, using the manubrial-Cs (CM2) bipolar lead with one electrode over the manubrium sterni and the other in the V5 position. Using a Hewlett-Packard EKG machine, ten-second tracings of the EKG were taken while the subjects were at rest on the ergometer (resting measurement) and at the end of every one-minute period.
TABLE 2

HEMODYNAMIC DATA ON PATIENTS

<table>
<thead>
<tr>
<th>PATIENT</th>
<th>DATE OF CATHETERIZATION</th>
<th>LVEDP (mm Hg)</th>
<th>LVEDV (ml/m²)</th>
<th>EF%</th>
<th>CONTRACTILITY BY LV CINEANGIOGRAPHY</th>
</tr>
</thead>
<tbody>
<tr>
<td>TM program group</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E.B.</td>
<td>April 1970</td>
<td>6</td>
<td>64</td>
<td>80</td>
<td>Normal</td>
</tr>
<tr>
<td>B.D.</td>
<td>December 1970</td>
<td>10</td>
<td>90</td>
<td>72</td>
<td>Normal</td>
</tr>
<tr>
<td>J.D.</td>
<td>May 1974</td>
<td>8</td>
<td>73</td>
<td>78</td>
<td>Normal</td>
</tr>
<tr>
<td>J.G.</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>C.J.</td>
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<td>87</td>
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</tr>
<tr>
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<td>8</td>
<td>70</td>
<td>61</td>
<td>Normal</td>
</tr>
<tr>
<td>C.M.</td>
<td>December 1973</td>
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<td>55</td>
<td>83</td>
<td>Normal</td>
</tr>
<tr>
<td>G.P.</td>
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<td>73</td>
<td>76</td>
<td>Normal</td>
</tr>
<tr>
<td>L.W.</td>
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<td>54</td>
<td>Moderate Anterior and Apical Abnormality</td>
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<tr>
<td>J.Z.</td>
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<td>16</td>
<td>92</td>
<td>42</td>
<td>Severe Posterior Abnormality</td>
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<tr>
<td>Control group</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>86</td>
<td>69</td>
<td>Normal</td>
</tr>
<tr>
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<td>51</td>
<td>Normal</td>
</tr>
<tr>
<td>W.G.</td>
<td>May 1974</td>
<td>8</td>
<td>60</td>
<td>58</td>
<td>Moderate Posterior Abnormality</td>
</tr>
<tr>
<td>C.L.</td>
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<td>10</td>
<td>56</td>
<td>60</td>
<td>Normal</td>
</tr>
<tr>
<td>M.S.</td>
<td>April 1973</td>
<td>10</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>S.W.</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
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</table>

ABBREVIATIONS: EF% = Ejection Fraction in percent; LV Cineangiography = Left Ventricular Cineangiography; LVEDP = Left Ventricular End Diastolic Pressure; LVEDV = Left Ventricular End Diastolic Volume.

*Coronary arteriography not performed.

during the test. At the exact end point of the test, a one-minute tracing was taken. Patients were instructed to use grades 1+, 2+, and 3+ for mild, moderately severe, and severe angina, respectively. All were exercised to 2+ angina. The patients were questioned directly as to the presence of angina once every minute during the test after the measurements were made.

In an attempt to avoid observer bias, all testing was done without referring to the results of previous tests. The only data available at the time of testing were the patient’s own individual work load schedule and the position of the V5 electrode as measured from the mid-sternal line.

Eight parameters were measured on each test (see table 3). Duration of exercise was measured in minutes to the exact end point of exercise, which was at 2+ angina. The maximum work load obtained was expressed in kpm (kilopound meters). The onset of ST segment depression was timed in minutes. This measure is an indicator of oxygen deprivation in cardiac tissues. The maximum ST depression was expressed in millimeters of horizontal depression, measured from the PQ segment of the electrocardiogram. The double product was obtained by multiplying heart rate by systolic blood pressure and dividing by 100, and was calculated from values obtained while the subject was resting on the bicycle at the beginning of the test, at three minutes, six minutes, and at maximum levels.

Multiple tests were done on both groups in the pre-TM program period—the period before the TM program group learned the TM technique. Testing was done on separate days except for those patients who, because of travel considerations, had two tests on the same day. In the latter case each test was separated by at least a two-hour rest period. After preliminary tests, all patients had at least two tests in the pre-TM program period that met the criteria for acceptability, and many had three tests. Criteria for acceptability of tests were (a) at least one prior test, (b) absence of any intercurrent illness, (c) omission of antianginal drugs, (d) horizontal or down-slanting ST segment depression of at least 1 mm, and (e) absence of significant arrhythmia.

TREATMENT—Patients in the TM program group received a course of instruction in the Transcendental Meditation technique, as taught by Maharishi Mahesh Yogi. The instruction was given by trained teachers of the World Plan Executive Council, a nonprofit educational organization (National Center, 17310 Sunset Boulevard, Pacific Palisades, California 90272). Except for one day of individual instruction, the entire course was given in the hospital setting. The course included two one-hour introductory/preparatory lectures, one individual one-hour session of personal instruction in the technique, three two-hour group sessions, held on consecutive days after learning the technique, and a follow-up individual one-half hour session of verification and validation of the practice on a biweekly, then monthly, basis. Group meetings were held every three months.
FIG. 1. INTERTEST VARIATION FOR BOTH THE PRE- AND POST-TM PROGRAM PERIODS. The light bars represent mean values for the TM program group in the pre- and post-TM program periods. The dark bars represent mean values for the control group in pre- and post-TM program periods.

FIG. 2. THE EFFECT OF THE TRANSCENDENTAL MEDITATION PROGRAM ON THE DURATION OF EXERCISE. Closed circles represent the mean value for duration of exercise for the two or more tests on each individual patient in the pre- and post-TM program periods. Open circles with bar represent group means.
During the TM program period the control group was followed in the usual manner in the cardiology clinic. Although they did not receive instruction in the TM technique, they did hear two initial group lectures. The patients in the TM program group were instructed to practice the TM technique 20 minutes twice a day on their own, as is the usual practice.

Retesting for both groups was performed between six and eight months after the course of instruction in the Transcendental Meditation technique (called the post-TM program period). The test protocol was exactly the same and was performed without prior knowledge of previous test results, except for individual work load schedules and position of the electrode. Individual tests were again done on separate days and in some cases were separated by weeks or months. In the post-TM program period, all patients had at least two tests that met the criteria for acceptability; many had three tests.

ANALYSIS—Data were first analyzed for reproducibility. Data within each parameter for all tests in the pre-TM program period were compared in pairs using a t-test corrected for small numbers and unequal groups. Individual intertest variation of the data within each parameter was not significant for either group. Thus, the validity of the mean values for all test data for each individual patient was determined. A similar analysis on all tests in the post-TM program period was performed. Again the data revealed no significant individual intertest variation and therefore were similarly meanded. Group means were then determined for each parameter, and statistical analysis on the group means for each parameter between the TM program and control groups was done using a t-test corrected for small numbers and unequal groups. In addition, a paired t-test was done on individual patient mean values for each parameter in the pre-TM program and the post-TM program periods. In this manner, the patient served as his own control.

RESULTS

Reproducibility of all test results within each period was excellent. Individual intertest variation in both groups within the pre-TM program and post-TM program periods was not significant for any of the eight parameters measured. This can be seen in fig. 1, which represents the mean value for each of the three tests in the pre-TM program and post-TM program periods for duration of exercise and maximum double product. Figure 2 illustrates changes for each patient in the duration of exercise in both the TM program and control groups. All but one patient in the TM program group increased the duration of exercise. In contrast, the control group showed essentially no change after an eight-month period.

The mean increase in duration of exercise in the TM program group was 1.02 minutes or 14.5% (see table 3), which is highly significant (p < .001). In addition, the TM program group increased significantly in maximum work load by 11% (p < .05), and onset of ST segment depression was delayed by 55 seconds or 16% (p < .01).
In the pre–TM program period there was no significant difference between the TM program group and the control group. In addition, no significant changes occurred in the control group upon retesting after six to eight months. Figure 3 represents the percentage of change in exercise capacity for both groups in the post–TM program period.

Furthermore, the two parameters that were measured at the end point of the test, i.e., maximum ST segment depression and maximum double product, showed no significant variation in the TM program group after six to eight months of the TM program (see table 3). The control group also showed no variation in these parameters.

The double product while subjects were at rest on the ergometer showed no change after subject participation in the TM program, but the three-minute double product was significantly lower \((p < .02)\). When the TM program group was compared to the control group, in the post–TM program period, the six-minute double product was also significantly lower \((p < .01)\) (see table 3). The change in hemodynamic response throughout the duration of the test is illustrated in fig. 4. The effect of the TM program was to lower the three- and six-minute double products. This modification of the hemodynamic response to stress thus delays the development of angina. However, the end point of the exercise occurs at a double product that is unchanged from pre–TM program values. As is illustrated in fig. 5, the control group showed essentially no change upon retesting.

**Clinical Observation**—The patients in the TM program group reported less anxiety, less need for tranquilizers, improved sleeping patterns, and improved personal interrelationships. Acceptance of the practice of the TM technique was high, with only one patient reporting marked irregularities in the frequency of the practice. The majority reported less use of nitroglycerin, although quantification of this was difficult to assess.
DISCUSSION

Our data suggest that the regular practice of the Transcendental Meditation technique is associated with a modification of the hemodynamic response to stress and an increase in exercise capacity in patients with stable angina pectoris. The effect is statistically significant and is measurable after six to eight months of the practice of this mental technique. In this preliminary investigation, multiple exercise tests were performed in both the pre-TM program and post-TM program periods, and data were analyzed with each patient serving as his own control, and with the TM program group compared to a control group.

The Transcendental Meditation technique produces immediate and pronounced metabolic and hemodynamic changes (30). The physiological correlates of the mental state (described as restful alertness) produced by the Transcendental Meditation technique indicate a general state of quiescence of the sympathetic nervous system (31, 32), characterized by increased basal skin resistance, decreased arterial blood lactate (33), and increased forearm blood flow (20). It has been hypothesized that the decrease of sympathetic tone indicated by these measurements is an opposite to the "fight or flight" response described by Walter B. Cannon.

However, there are ramifications that go beyond this concept, since specific EEG correlates during the practice of the Transcendental Meditation technique seem to indicate a unique hemispheric synchrony, as well as increased alpha and theta activity, changes that have not been seen with any other mental practice or response (1, 13). The practice of this mental technique seems to produce both immediate and long-term physiological and psychological effects.

Skin resistance response patterns have shown that the sympathetic response to stress is decreased in subjects regularly practicing the Transcendental Meditation technique (22). Also, a documented antihypertensive effect has been demonstrated in both treated and untreated hypertensive patients (2, 4, 5). Individuals practicing the TM technique have relatively low blood pressure (32), which also suggests decreased sympathetic activity. Parameters of pulmonary function in asthmatic patients are also affected by the TM technique; e.g., airway resistance decreases and forced expiratory volume increases (35). This effect would not be predicted if the action of the Transcendental Meditation technique were based solely on decreased sympathetic tone. Multiple mechanisms have been proposed by Wilson et al. to explain this effect (35).

Emotional stress, anxiety, and type A behavior are presumed triggers of the "fight or flight" response and would also contribute to increased sympathetic activity in the angina patient. Therefore, the improved psychological functioning and reduction in anxiety levels resulting from the Transcendental Meditation program, as noted in this study as well as by Glueck and Stroebel (13), may in themselves contribute to the physiological benefits found here.

Improvement in exercise performance in patients with angina pectoris through modification of the determinants of myocardial oxygen consumption (MVO₂) is well documented (10, 15, 29). Factors that modify the major determinants of MVO₂ (ventricular wall tension, heart rate, contractility) reduce ischemic manifestations in the myocardium which have resulted from restricted blood flow through diseased vessels during the demand of exercise.

Physical conditioning (7, 11, 23), nitrates (9, 16), and beta sympathetic blockade (14, 17) produce modifications in the hemodynamic response to stress and exercise. MVO₂ is therefore lower at any given level of stress or exercise work load, and ischemic manifestations such as angina are delayed. Sympathetic tone affects the determinants of MVO₂ and exerts an essential role in the hemodynamic response to stress and exercise. Increased sympathetic activity causes increases in heart rate, myocardial contractility, and both systolic and diastolic blood pressure.

Mental states that alter physiological function in the direction of hypometabolism and reduced sympathetic tone therefore offer similar potential for such improvement in exercise capacity in individuals with angina pectoris. This may be the major effect operative with the Transcendental Meditation technique, which explains the increase in exercise performance. Although not investigated in this study, increased blood flow in the myocardium may represent another possible mechanism of improved exercise performance, since preliminary work on forearm blood flow has shown that it increases during the Transcendental Meditation technique (32).

It seems unlikely that the improved hemodynamic response to exercise shown in our data can be ascribed to a placebo effect, since a study by Dagenais et al (8) found that a placebo effect reduced symptoms of angina, but did not improve exercise performance.

Robinson et al. (25) have demonstrated that the double product at onset of angina is constant. In addition, more recent studies (18, 21, 24) have demonstrated that the double product correlates well with the MVO₂. Thus, by comparing double products, the effect of any therapeutic modality on MVO₂ can be approximated.

Accurate assessment of improved exercise performance in angina pectoris requires reproducible exercise testing. In patients with stable angina, Epstein et al.
(10) and Blomqvist and Atkins (6) have shown that exercise capacity does not vary significantly over several months of observation. Redwood et al. (24) have shown that for an exercise test to be really reproducible, a proper protocol is required. Using onset of angina as an end point, or the first initial test, Smokler et al. (27) found poor reproducibility of results, a finding substantiated by Dagenais et al. (8), who observed variations of up to 17% in duration of exercise. Smokler et al. found, however, that an end point of moderately severe angina ensured reproducibility, with an average percentage of variation of 5.4%. It appears that there is more possibility of subjective variation with a minor degree of discomfort than with the unmistakable reality of moderately severe angina.

The reliability of our test data in measuring changes in exercise performance was documented with the close reproducibility of the two or more tests within each period. Also, the control group did not vary significantly after an eight-month period, again documenting reproducibility of the testing protocol. Parameters that documented reproducibility of the end point of the test induced maximum double product and maximum ST segment depression, which did not vary significantly upon retesting. The consistency of these measures across trials allows the conclusion that the patients were exercised to the same degree of angina during the pre- and post-tests. The improvement in duration of exercise for the TM program group therefore represents a real change in the patients' condition.

At each work load the double product was reduced, and this increase in performance was corroborated by other parameters including an increase in the maximum work load (11%) and a delay in the onset of ST segment depression (16%). The mechanism for bringing about the improvement in exercise performance would therefore appear to be that the hypometabolism and reduced sympathetic tone resulting from the Transcendental Meditation technique modified the determinants of MVO₂, as suggested above. In this way the hemodynamic response to stress was reduced such that at every work load the double product was lower and thus, the anginal threshold was delayed.

The clinical observation that psychological improvement was evident in the TM program group is supported by other studies (13). Excess anxiety and type A behavior are common in angina patients and may even be characteristic of the syndrome (12). Thus, as a nonpharmacological approach to treat anxiety, and possibly to modify type A behavior, the Transcendental Meditation program offers additional positive benefits to patients with angina pectoris. In addition, other factors known to affect cardiovascular disease such as obesity (34), hypertension (4, 5, 26), and tobacco use (19) have all been demonstrated to decrease with the practice of the Transcendental Meditation technique.

Moreover, standardized instruction in the TM program is widely available. It is acceptable to patients, inexpensive, and easily learned. Furthermore, with adequate follow-up, compliance rate is high. The Transcendental Meditation program therefore can serve as an adjunctive form of therapy in the treatment of angina pectoris on both physiological and psychological levels.

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